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(54) Improvements in and relating to heat exchangers.

(57) There is disclosed an air conditioning unit for location in the wall of a room and which comprises a heat exchanger, an external supply fan (4) operable to blow air into the room through the heat exchanger (1) and an extract fan (5) operable to draw air out of the room through the heat exchanger (1), in which the heat exchanger (1) comprises a stack of thin flexible plates (7a, 7b) which are spaced apart from each other so as to define between opposed faces of adjacent plates extract air flow paths (9) and supply air flow paths (8) through the heat exchanger (1), with the spacing apart of the faces defining the extract air flow paths (9) being greater than the spacing apart of the faces defining the supply air flow paths (8) whereby the depth of the extract air flow paths (9) initially is greater than the depth of the supply air flow paths (8), but during operation any tendency for the flexible plates (7a, 7b) to deform under differential pressure action results in the depths of the extract air flow paths (9) and supply air flow paths (8) being substantially equalised, which provides more efficient heat transfer between the air flow paths.

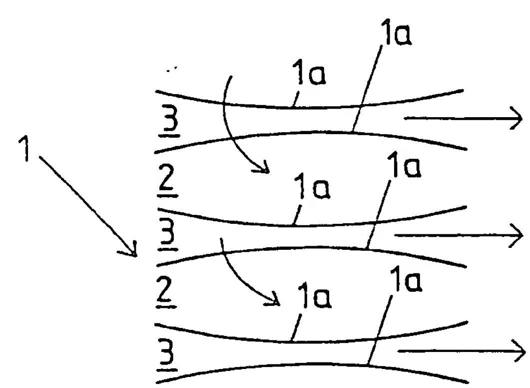

FIG. 2

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IMPROVEMENTS IN AND RELATING TO HEAT EXCHANGERS

The present invention relates to an improved heat exchanger of the type which comprises a stack of thin parallel plates, and particularly, though not exclusively, to such a heat exchanger intended to be incorporated in an air conditioning unit for supplying fresh air into and extracting stale air from an otherwise closed room, with heat exchange occurring between the incoming (supply) and outgoing (extract) air streams.

Air conditioning units of this type generally comprise two separate fans, namely a supply fan (blowing fan) and an extract fan (suction fan), and a heat exchanger through which the supply and extract air streams pass, generally in counterflow or cross flow fashion. Conventionally, heat exchangers for use in such air conditioning units comprise a stack of thin plates of metal such as aluminium or copper. Such heat exchangers have minimum resistance to air flow, thus allowing the size of the supply and extract fans, and thus the operating noise level, to be kept to a minimum. However, metal plate heat exchangers are heavy, expensive to manufacture, and the metal (especially aluminium) can be damaged by corrosive environments such as swimming pools.

One approach to this problem has been to use very thin plastic plates which are light, cheap to manufacture, and still offer very good heat transfer, these plates generally being heavily ribbed to increase the total surface area available for heat exchange. The plastic plates, which may be made from "nylon", PVC or any other suitable plastics material, are also advantageous in that they are resistant to corrosion.

The use of plastic plates has however created another problem. Because the plates are very thin they tend to flex easily, particularly about axes which are parallel to the ribs. When the plates are stacked together to form a heat exchanger, the plates define a plurality of supply flow paths and extract flow paths which are each made of narrow depth in order to maximise heat recovery i.e. only small spacing apart of the plates in the stack. The narrow flow paths and the flexibility of the plates (together with the differential pressure action of the supply and extraction fans) combine to result in the plate wall faces defining the supply flow path being blown wider apart and the faces defining the extract flow paths being drawn closer together during operation of the unit. This is thought to be due to the pressure differential between the supply and extract fans, and results in reduced extract flow rate and hence lower temperature efficiency. Usually, the supply and extract fans are both located on the outside of the heat exchanger, and one fan operates to blow air into the heat exchanger whilst the other fan operates to draw air from the heat exchanger. An attempt has been made to overcome the problem of the deformation of the flow paths, by placing the supply and extract fans one on either side of the heat exchanger. The supply and extract pressures are then much more balanced, since the two fans are each blowing air into the heat exchanger. However, this arrangement increases the total length of the unit which is unacceptable when the unit is designed to be installed in a wall, and also the location of a fan on the room side of the heat exchanger increases the operating noise level.

An alternative approach is to use a more powerful extract fan to overcome the resistance to flow produced by the narrowing of the extract flow paths. This approach is not acceptable as such an arrangement would have a high noise level and higher power consumption, and in addition the stronger extract fan can cause the distortion of the flow paths to increase, thus exacerbating the problem.

It is therefore the aim of the present invention to provide an improved heat exchanger which overcomes the above-mentioned disadvantages.

According to a first aspect of the present invention there is provided a heat exchanger for use in an air conditioning unit and which comprises a stack of thin flexible plates which are spaced apart from each other so as to define between opposed faces of adjacent plates first and second air flow paths through the heat exchanger, in which the spacing apart of the faces defining the first air flow paths is greater than the spacing apart of the faces defining the second air flow paths whereby the depth of the first air flow paths is greater than the depth of the second air flow paths.

According to a second aspect of the present invention there is provided an air conditioning unit for location in the wall of a room, and which comprises a heat exchanger and, mounted exteriorly of said heat exchanger, a supply fan operable to blow air into the room through the heat exchanger and an extract fan operable to draw air out of the room through the heat exchanger, in which the heat exchanger comprising a stack of thin flexible plates which are spaced apart from each other so as to define between opposed faces of adjacent plates alternate supply and extract air flow paths through which air is moved by said fans, the spacing apart of the faces defining the extract air flow paths being greater than the spacing apart of the faces defining the supply air flow paths whereby the depth of the extract air flow paths is greater than

the depth of the supply air flow paths.

By utilising extract air flow paths which are deeper than the supply air flow paths, the effects of plate distortion is minimized.

Preferably, the difference in the depth of the extract and supply flow paths is at least 1 mm.

The depth of the air flow paths would typically be, for an industrial unit, 5 mm for the supply paths and 6 mm for the extract paths, or, for a domestic unit, 3 mm for the supply paths and 4 mm for the extract paths.

Because an allowance is made for plate distortion, the extract flow rate is not significantly reduced, and the temperature transfer efficiency increases.

Preferably, the supply and extract fans are both axial flow fans. This type of fan is thinner and thus does not take up too much room in the unit, but does not operate against significant resistance to air flow. Thus, the reduced resistance to extract flow means that the axial flow fans are feasible.

Conveniently, the plates themselves are approximately 150 microns thick, but it should be appreciated that the reduced effects of plate distortion mean that even thinner plates may be used to improve heat transfer and reduce the weight and manufacturing cost of the unit.

Preferably, the plates are made from plastics material such as PVC, "nylon" or similar, and the edges of each pair of adjacent plates may be joined together over at least a part of their perimeter.

Conveniently, the plates each include a plurality of ribs running continuously and/or discontinuously across the plate.

An embodiment of the present invention will now be described, by way of example only, and contrasted with the prior art, with reference to the accompanying drawings in which:

Figure 1 is a cross section through a conventional heat exchanger;

Figure 2 is a cross section through the heat exchanger of Figure 1, in use:

Figure 3 is a schematic of a conventional air conditioning unit using the heat exchanger of Figures 1 and 2;

Figure 4 is a schematic of an alternative conventional air conditioning unit;

Figure 5 is an end view of a heat exchanger in accordance with the present invention;

Figure 6 is a cross section through the heat exchanger of Figure 5;

Figure 7 is a plan view of a first type of plate forming part of the heat exchanger of the present invention;

Figure 8 is a plan view of a second type of plate forming part of the heat exchanger of the present invention;

Figure 9 is a section on line A-A of Figure 7;

Figure 10 is a section on line B-B of Figure 7;

Figure 11 is a section on line C-C of Figure 10;

Figure 12 is a section on line D-D of Figure 7;

Figure 13 is a section on line E-E of Figure 8;

Figure 14 is a section on line G-G of Figure 7;

Figure 15A illustrates one type of joint between two adjacent heat exchanger plates;

Figure 15B illustrates an alternative type of joint between adjacent heat exchanger plates;

Figure 15C illustrates a further alternative type of joint between adjacent heat exchanger plates;

Figure 16 is a plan view of a rigid former used to secure the plates in a stacked arrangement in the air conditioning unit;

Figure 17 is a section on H-H of Figure 16;

Figure 18 is a perspective view of the plate shown in Figure 8.

Referring to the drawings, Figures 1 and 2 illustrate the problem of plate deformation in a conventional heat exchanger 1 comprising a stack of thin flexible plastic plates 1a. These plates define between opposed faces of adjacent plates alternate supply 2 and extract 3 air flow paths through which air is blown by supply fan 4 and drawn by extract fan 5 as shown in Figure 3. Because fan 4 is blowing air through the heat exchanger whilst fan 5 is sucking air into the heat exchanger, there is a pressure difference between flow paths 2 and 3 which causes the plates to bend as shown in Figure 2, thus restricting the extract flow paths 3 resulting in reduced temperature efficiency or thermal transfer.

Figure 4 shows one approach to the problem which is to locate the supply fan 4 and extract fan 5 on opposite sides of the heat exchanger. This approach is not acceptable because of the increased length of the unit and also the noise level.

As shown in Figures 5 and 6, a heat exchanger according to the present invention comprises a stack of thin flexible plastic plates 7 of which there are two types 7a and 7b stacked alternately. These plates define between them alternate supply 8 and extract 9 flow paths, and the spacing apart of the plates 7a, 7b varies alternately so that the opposed faces which define paths 9 are further apart than the opposed face which defin paths 8. Therefore, the extract paths 9 are made wider than the supply paths 8 by approximately 1 mm.

Thus, when the fans 4 and 5, which would typically be arranged as shown in Figure 3, are operated, the plates still deform under the differen-

tial pressure action on each plate caused by positive pressure on one side and negative on the other. However, the resultant effect is that the depths of the two air flow paths 8 and 9 become approximately equal since the extract path 9 is initially deeper. Thus, there is no appreciable increase in resistance to extract flow along extract path 9 and thus the temperature efficiency of the heat exchanger is increased.

As shown in Figure 7, one type of plate 7a includes a plurality of ribs 10 running across the plate to provide a certain degree of stiffness. Further ribs 11 are also provided which are larger than ribs 10, to provide stiffness and also to separate the adjacent plates. The ribs 11 may be continuous, as in plate 7b in Figure 8, or discontinuous as in Figure 7. Ribs 12 provide support and plate separation at the flow entry and exit points, and ribs 13 provide support and plate separation at the corners.

To enable large numbers of these Plates 7a, 7b to be assembled one on top of the other, plate to plate location means 14 in the form of two small circular protrusions are provided on each plate, these nesting together to provide the necessary location for the stacked plates.

Plate 7b illustrated in Figure 8 is similar to plate 7a in that it is provided with similar ribs 10′, 11′, 12′ and 13′ and location means 14.

However, the ribs 10′ and 11′ run approximately perpendicular to the ribs 10 and 11 of plate 7a. By arranging for ribs 11′ to be taller than ribs 11 by approximately 1 mm, the extract flow path 9 can be made approximately 1 mm deeper than the supply flow path 8.

When plate 7a is stacked on top of plate 7b, edges 15 and 16 of plate 7a are enclosed within folded edges 17, 18 of plate 7b but edges 19, 20 of plate 7a are spaced from edges 21, 22 of plate 7b by ribs 11′ to define supply flow path 8. Similarly, when a further plate 7b is stacked on top of plate 7a, edges 21, 22 of plate 7b are enclosed within folded edges 19, 20 of plate 7a but edges 17, 18 of plate 7b are spaced from edges 15, 16 of plate 7a by ribs 11 to define extract flow path 9. By stacking a number of plates 7a, 7b alternately one on top of the other the arrangement of Figure 5 is achieved.

As shown in Figure 15A, one type of joint between adjacent plates 7a, 7b is a simple butt joint in which the edges 22 and 19 are aligned. In Figure 15B, the edge 22 is freely located, but not welded, within edge 19 which is bent back over the top of edge 22. This arrangement is much better than that shown in Figure 15A because it provides a radius edge to give minimum air resistance and provide three layers at the edge for improved edge stiffness.

Figure 15C illustrates the most preferred form of joint in which the folded technique of Figure 15B is used but the edges 19 and 22 are welded together, to provide a joint which is smooth, stiff and air tight.

The edges of all the plates 7a, 7b are held together at each corner by a rigid plastics former 25 which is shown in Figures 16 and 17. The former has slots 26, 27, 28 and 29 which engage with protrusions on the top and bottom plates enclosing the stack of heat exchanger plates, and the inside of the former has a concavely curved section to provide a longitudinal recess 25a bounded by longitudinal ribs 25b. During assembly, a polyurethane sealant or similar substance is extruded into the recess along the length of the former, and the edges of the heat exchanger plates are pressed into the sealant to form a stiff corner section.

Claims

1. A heat exchanger for use in an air conditioning unit and which comprises a stack of thin flexible plates which are spaced apart from each other so as to define between opposed faces, of adjacent plates first and second air flow paths through the heat exchanger, in which the spacing apart of the faces defining the first air flow paths is greater than the spacing apart of the faces defining the second air flow paths whereby the depth of the first air flow paths is greater than the depth of the second air flow paths.

2. An air conditioning unit for location in the wall of a room, and which comprises a heat exchanger and, mounted exteriorly of said heat exchanger, a supply fan operable to blow air into the room through the heat exchanger and an extract fan operable to draw air out of the room through the heat exchanger, in which the heat exchanger comprising a stack of thin flexible plates which are spaced apart from each other so as to define between opposed faces of adjacent plates alternate supply and extract air flow paths through which air is moved by said fans, the spacing apart of the faces defining the extract air flow paths being greater than the spacing apart of the faces defining the supply air flow paths whereby the depth of the extract air flow paths is greater than the depth of the supply air flow paths.

3. An air conditioning unit according to Claim 2, in which the difference in the depth of the extract and supply flow paths is at least 1mm.

4. An air conditioning unit according to Claim 2 or 3, in which the plates are spaced apart at required spacings from each other by means of a plurality of ribs running continuously and / or discontinuously across the plates.

5. An air conditioning unit according to any one

of Claims 2 to 4, in which the plates are made of plastics material and are approximately 150 microns thick.

6. An air conditioning unit according to any one of Claims 2 to 5, in which the edges of each pair of adjacent plates are joined together over at least a part of their perimeter.

7. An air conditioning unit according to any one of Claims 2 to 6, in which the supply and extract fans are each axial flow type fans.

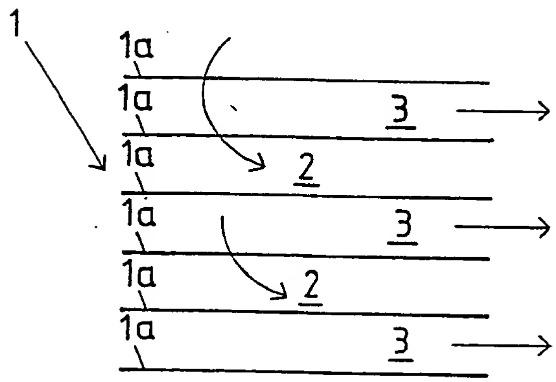

FIG. 1

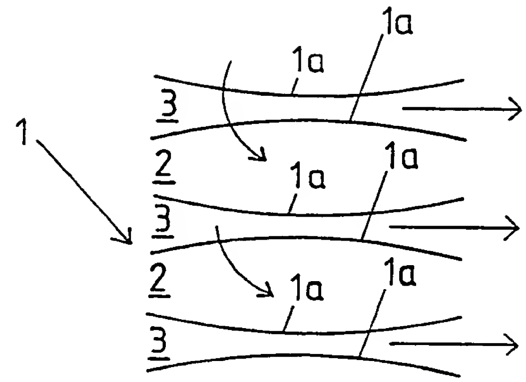

FIG. 2

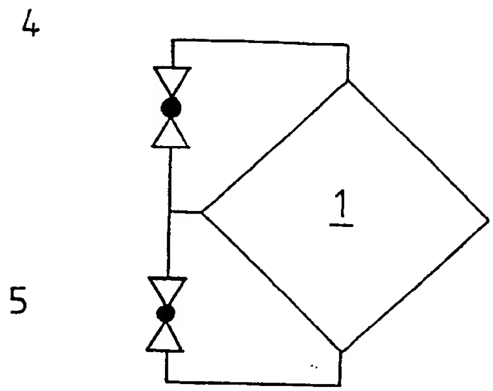

FIG 3

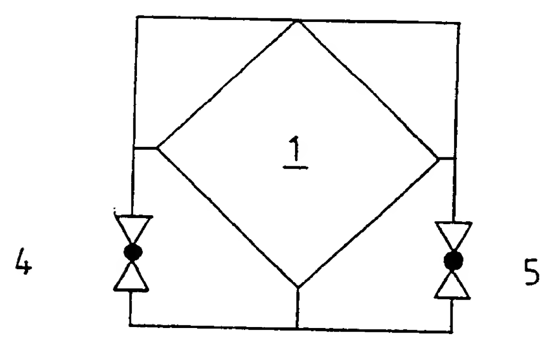

FIG. 4

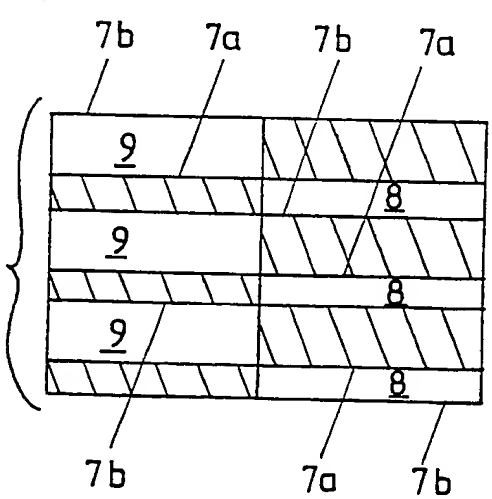

FIG. 5

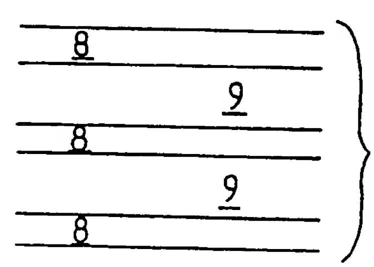

FIG. 6

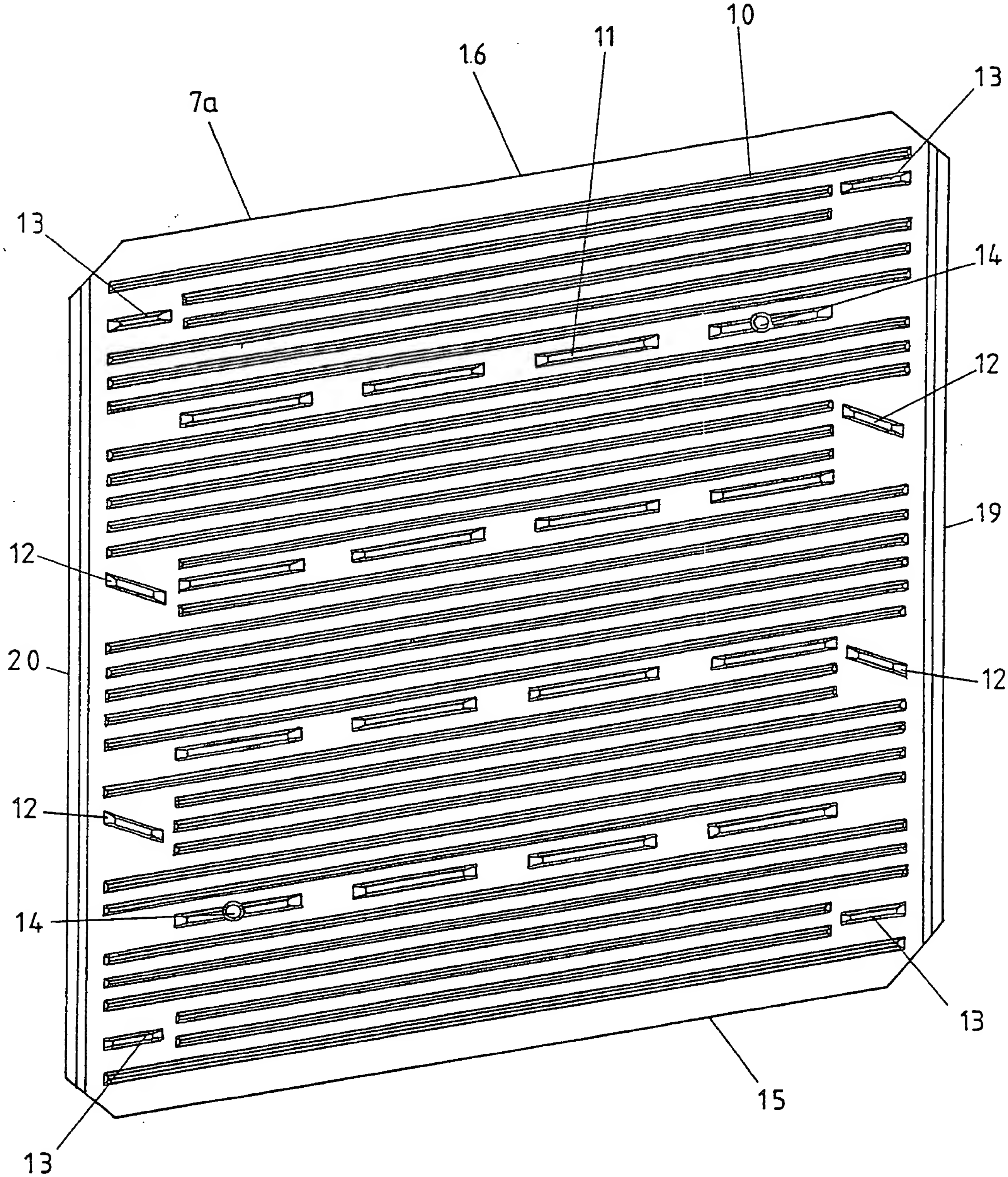

FIG. 7

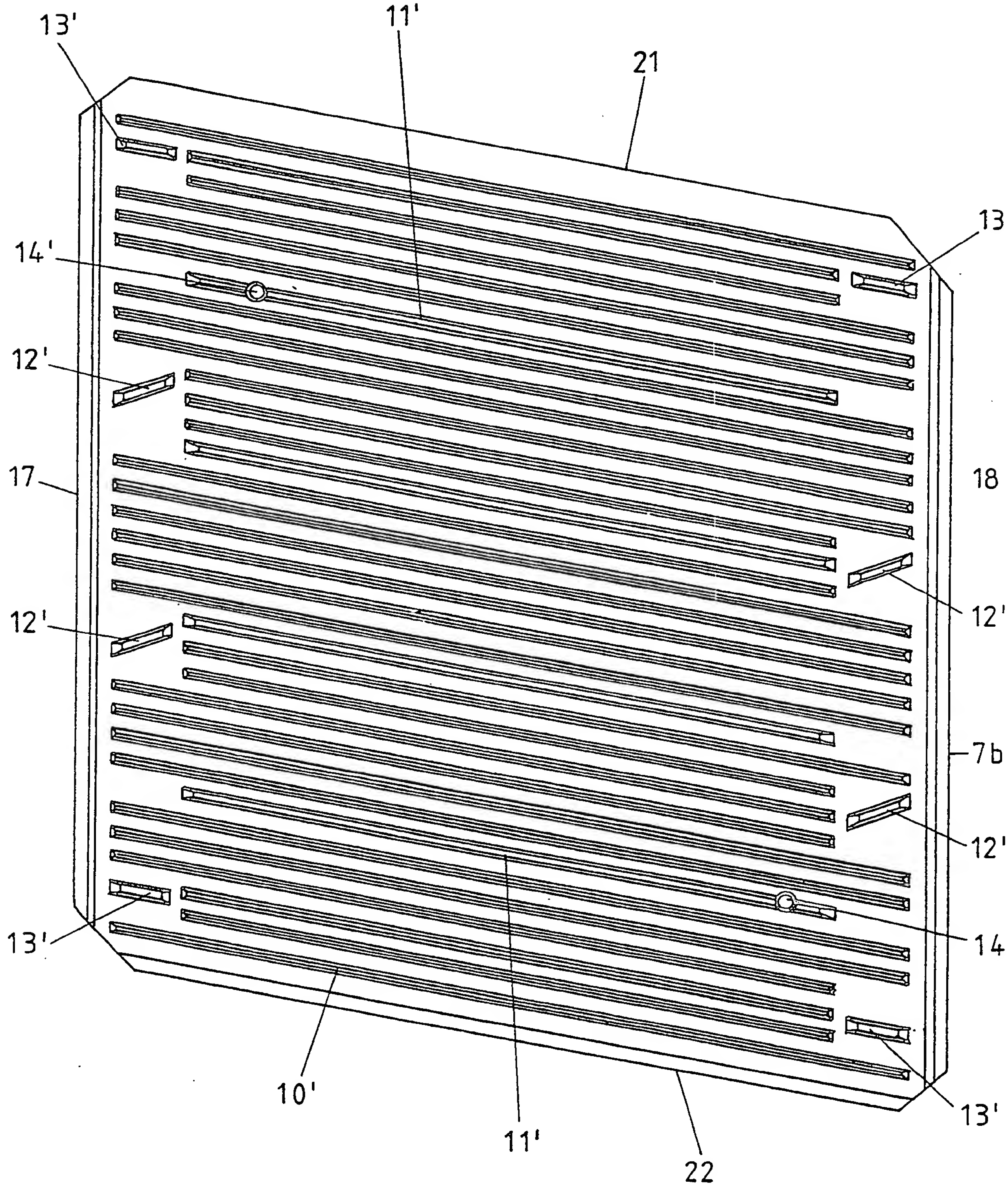

FIG. 8

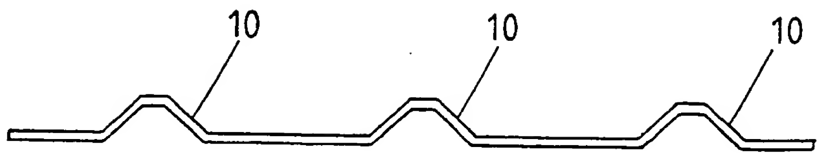

FIG. 9

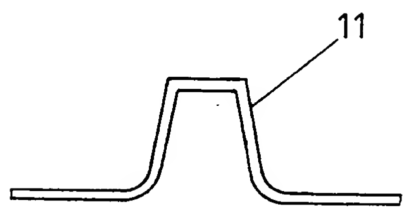

FIG. 10

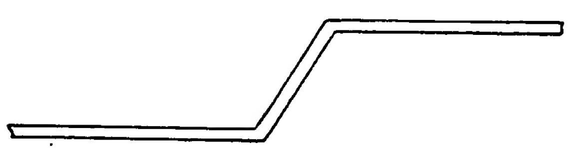

FIG. 11

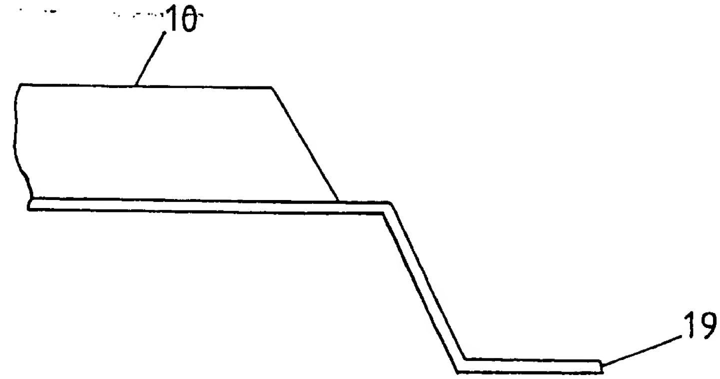

FIG. 12

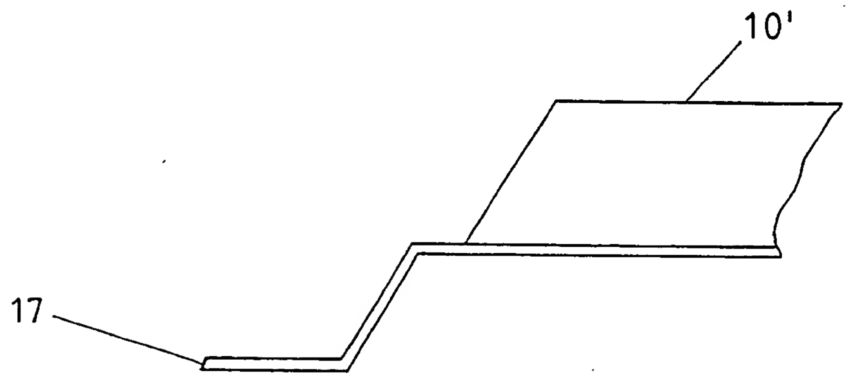

FIG. 13

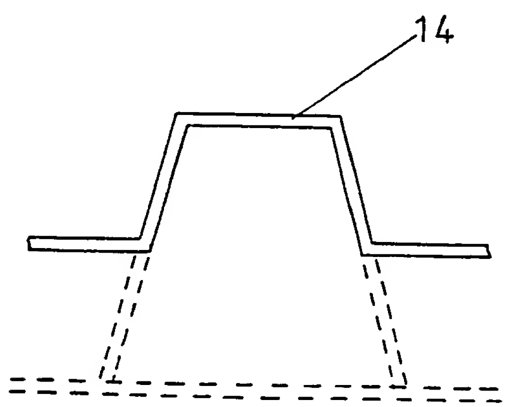

FIG. 14

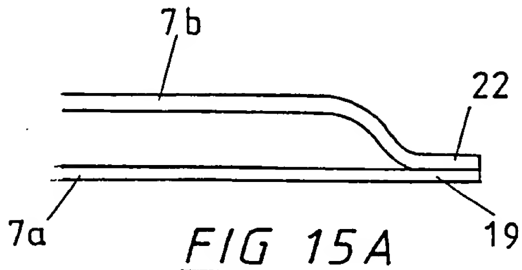

FIG 15A

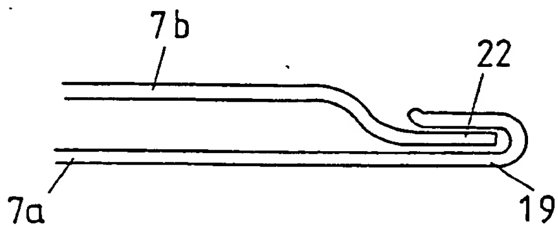

FIG. 15B

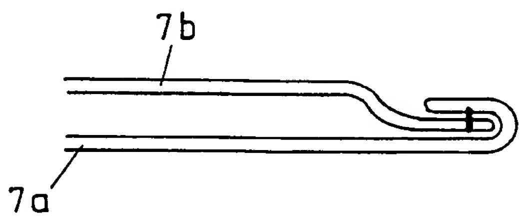

FIG. 15C

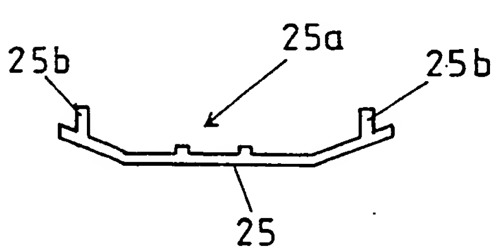

FIG. 17

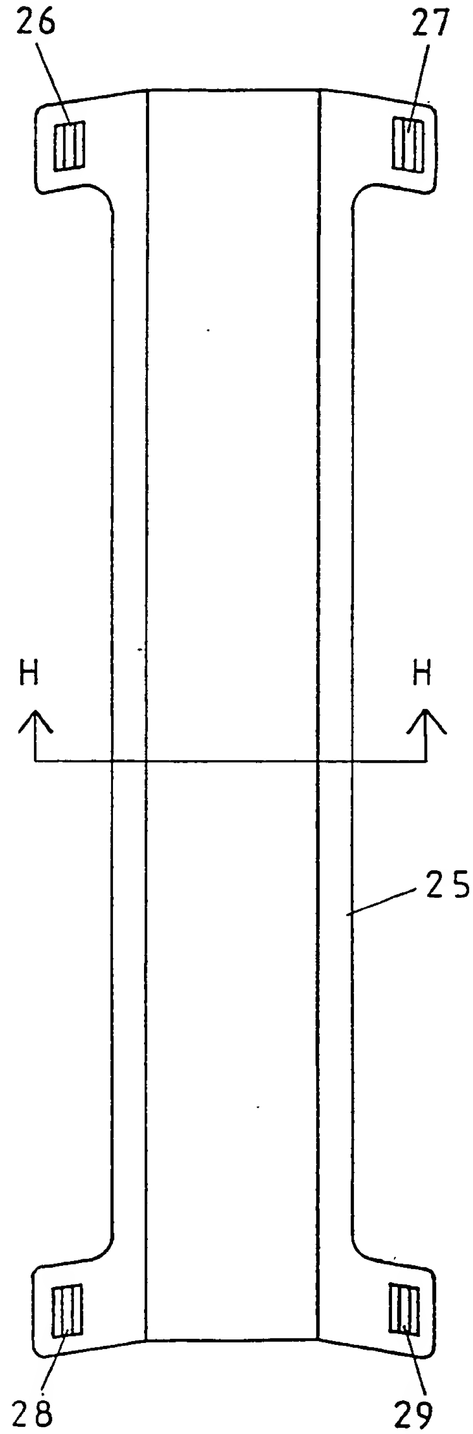

FIG. 16

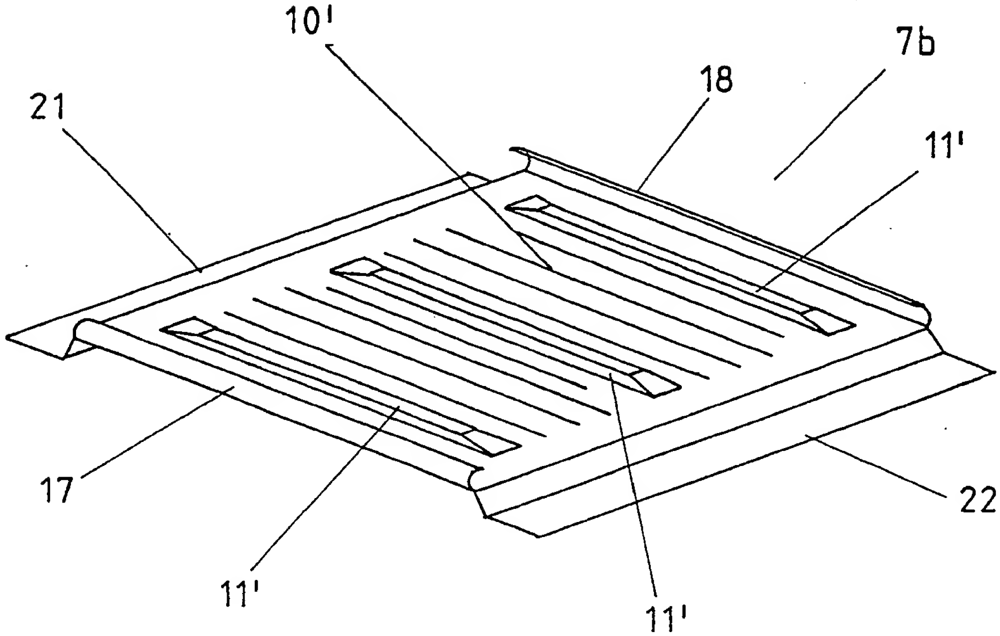

FIG. 18

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 89 31 0386

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	EP-A-0 208 042 (HAMON-INDUSTRIES) * Abstract; rev. 1; fig 11,14 * ---	1,2	F 28 F 3/08 F 28 D 9/02
A	US-A-3 814 172 (THE A.P.V. COMPANY) * Abstract; fig. 2 * ---	1,2	
A	EP-A-0 047 073 (ALFA-LAVAL) ---		
A	EP-A-0 167 993 (FISCHBACH) -----		
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			F 28 F F 28 D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	11-01-1990	HOERNELL, L.H.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

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